Augmented Reality Tower Tool (ARTT)

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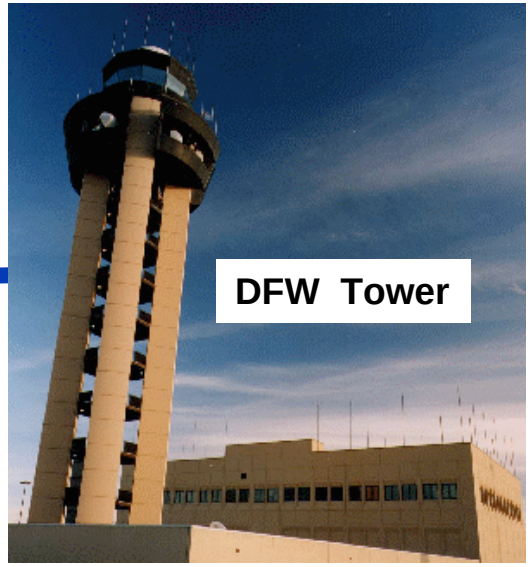
1. **The Airport Control Tower Task**
   - **1.1. Current structures and functions**
   - **1.2. Low Visibility Tower Tool Development**
2. **The Case of the Cockpit HUD**
   - **2.1. Early cockpit instrumentation**
   - **2.2. Proliferation of instruments**
   - **2.3. Benefits of HUD**
     - *2.3.1. Placement of information*
     - *2.3.2. Integration of information*
     - *2.3.3. Extended operational envelope*
3. **Information Integration in the Airport Tower**
   - **3.1. Displays in the control tower**
   - **3.2. Benefits of HUD**
     - *3.2.1. Placement of information*
     - *3.2.2. Integration of information*
     - *3.2.3. Extended operational envelope*
4. **Research Strategy**
   - **4.1. Constraint identification**
   - **4.2. Demonstration system**
   - **4.2. Interface testing**

Air Traffic Control Tower



- **Primary Task: SURFACE CONTROL**
- **Very Little 'AIR Traffic' Control**
- **Multiple Surveillance Systems**

- **Controllers MUST look out windows, even in Low or Zero Visibility Condition**
- **ATCT is the only ATC Domain where unmediated visual contact is regulated.**

Low Visibility Tower Tool

- Functions:
  - Full Scale ‘Virtual Tower’ Field Of View
  - Cover Surface, Approaches & Departures
  - Maintain Safety & Efficiency of Surface Operations during Adverse Visibility
- Benefits
  - Reliable Surface Capacity in all weather
  - Reduced Taxi-Times and Departure Queues
  - Reduced Delays, Holds, and Cancellations
  - Reduced Fuel Consumption, Increased Throughput

Situation Awareness Virtual Environment

SAVE displays aircraft position as 'cubes' (1998)
(http:ic-wwws.arc.nasa.gov/projects/SAVE)

- **Proof of Concept for Internet technologies for portable 3-D ATM displays.**
  - Java, VRML (aka Web3D), Browser 'Virtual Machine' Viewer
- **Real-Time Interface to Atlanta TRACON Airport Surveillance Radar**

Augmented Reality Tower Tool In Moffett Field ATC Tower

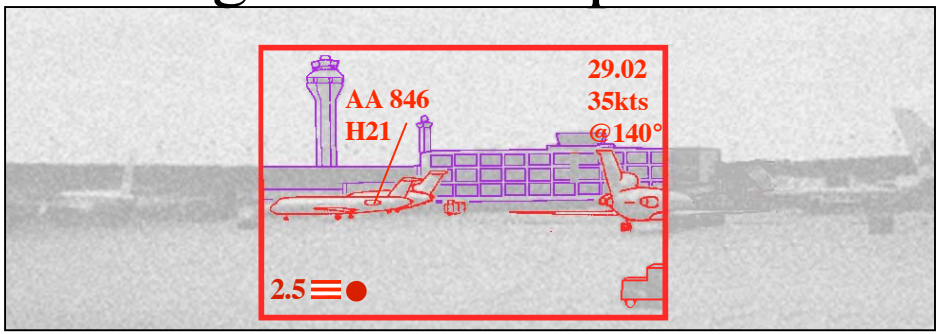
- **Spiral development in the field**
- **"Real World" conditions to test/develop optics**
- **Alphanumeric, 2-D, and 3-D symbology**
- **Controller Feedback and Evaluation**
- **Wireless / Wearable Prototype Development**

Extending the Field of View of a Tower HMD

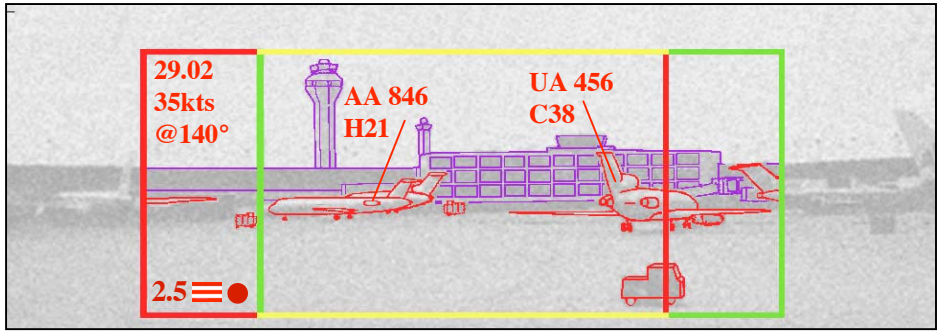
Airport View

Low Visibility Airport View

Augmented Airport View



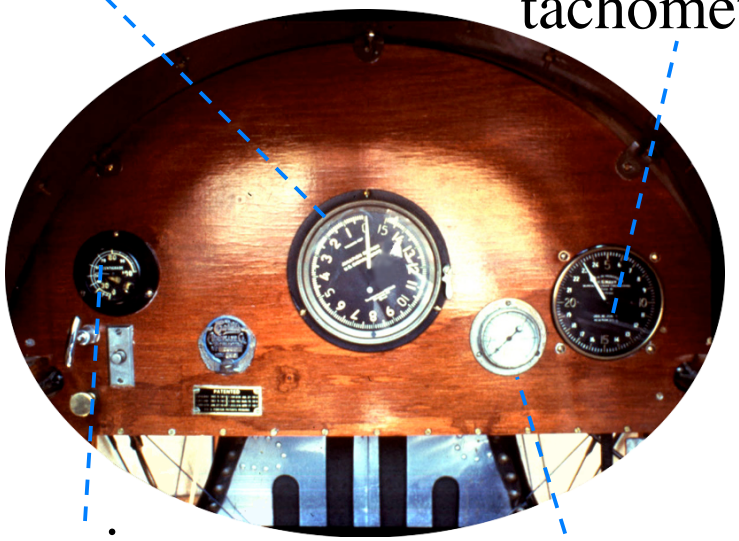
Extended FOV w/ Data Fields



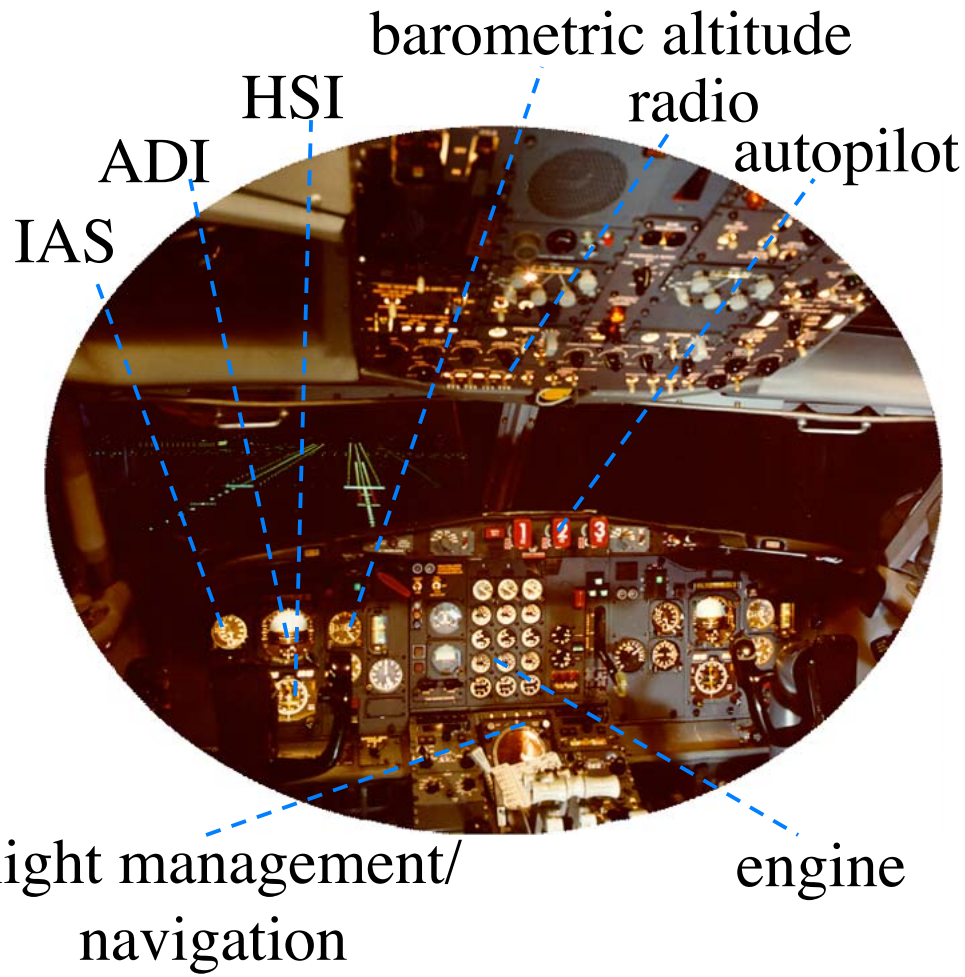
- **Augmented Reality: appropriate technology for low-visibility tower tool.**
- **Partial overlap display systems can extend Field of View**

Conventional Cockpit Instrumentation

Curtiss “Jenny”
1917



Boeing 727
1963+



Heads-Up Displays

Flight Dynamics (Bray) HUD

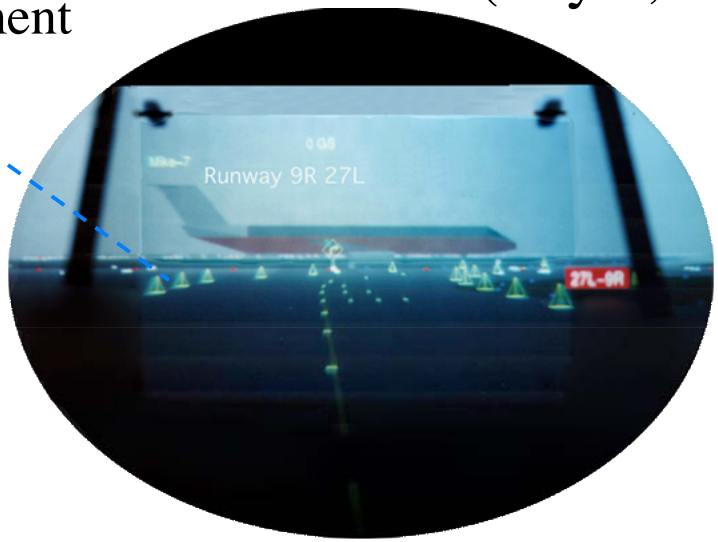
Inertially referenced element

VMS Simulator Cab

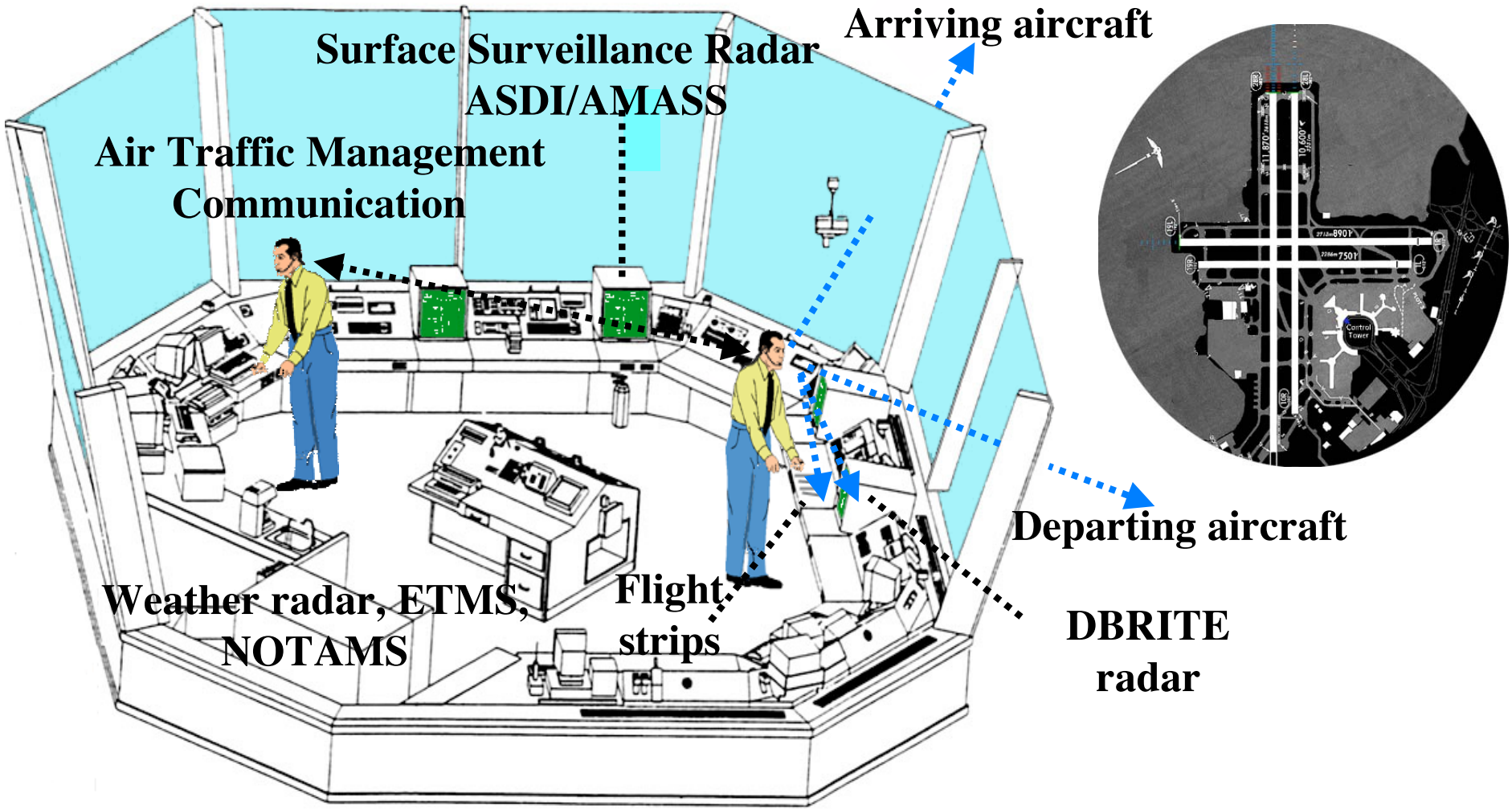
Conformal element

Geographically referenced element

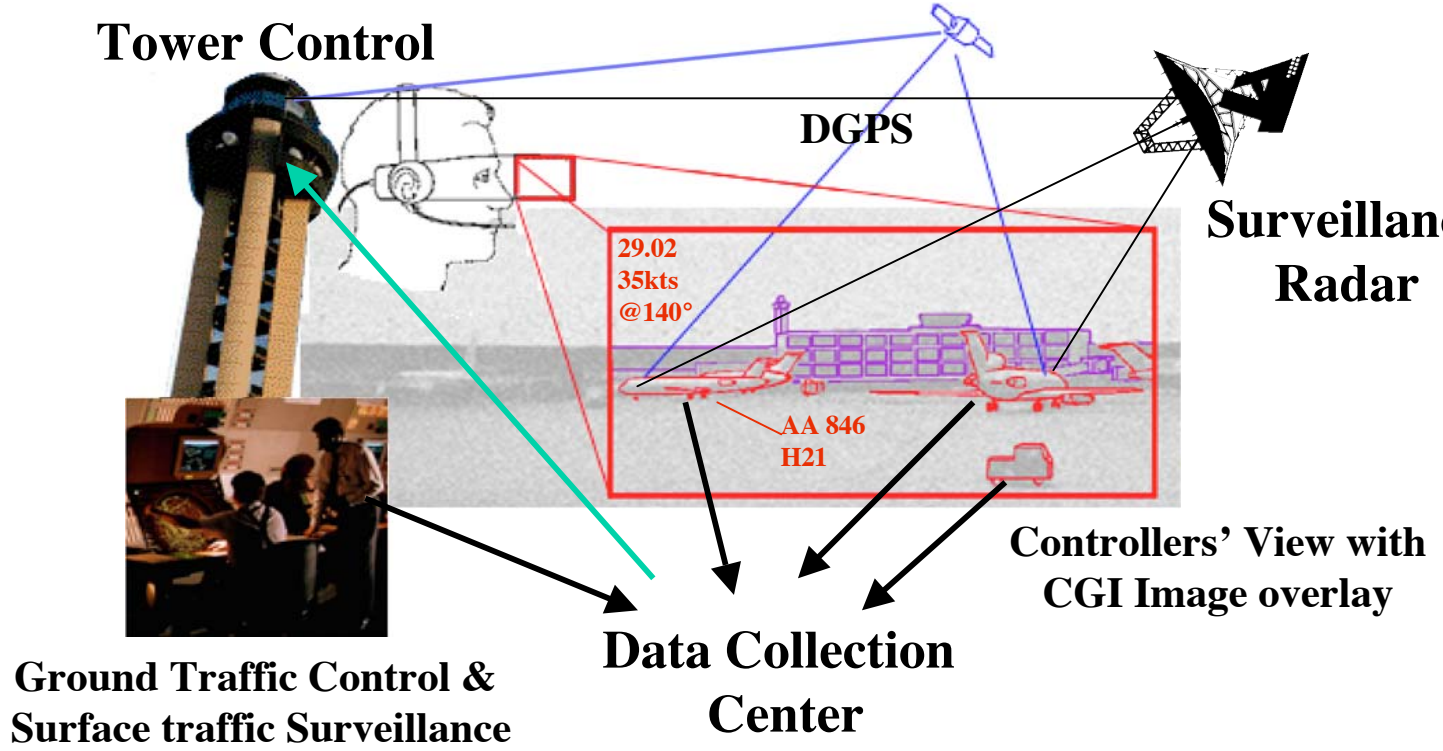
T-NASA(Foyle, et al)



Some Information Sources in the Tower



Augmented Reality Tower Tool (ARTT)



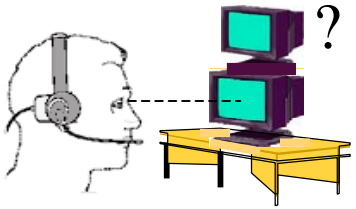
Some Possible Benefits

- **Better display integration/placement**
- **Improved low visibility operations**
- **Reduced controller memory load**
- **Virtual display surfaces / X-ray vision**

After diagram by Seagull Technology

Some Formats for Tower Augmented Reality

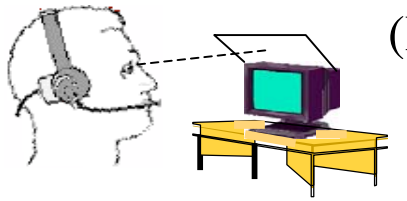
Video Mix



Pros
- Integrated format
- Technically simplest
- Conventional viewing

Cons
- Heads down
- Added occlusion (?)
- Complex view control

Console-mounted HUD

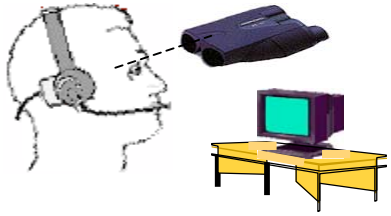


(Hitchcock)

Pros
- Integrated format
- Heads up
- Conformal imagery

Cons
- Virtual imagery
- Restricted viewbox
- Narrow field of view (FOV)

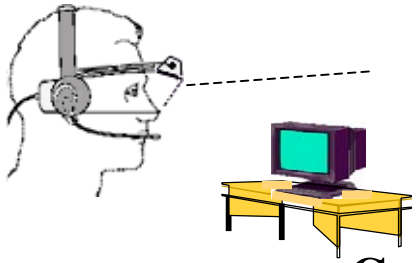
Electronic Binoculars



Pros
- Integrated format
- Heads up
- Conformal imagery
- Unrestricted viewbox
- Intuitive view control
- Unrestricted field of regard (FOR)

Cons
- Hand held
- Technically complex
- Virtual imagery
- Restricted field of view ?

Head-mounted HUD



Pros
- Integrated format
- Heads up
- Conformal imagery
- Unrestricted view box
- Unrestricted/wide FOV/FOR
- Intuitive view control

Cons
- Technical most complex
- Virtual imagery
- Individualized mount
- New ergonomics

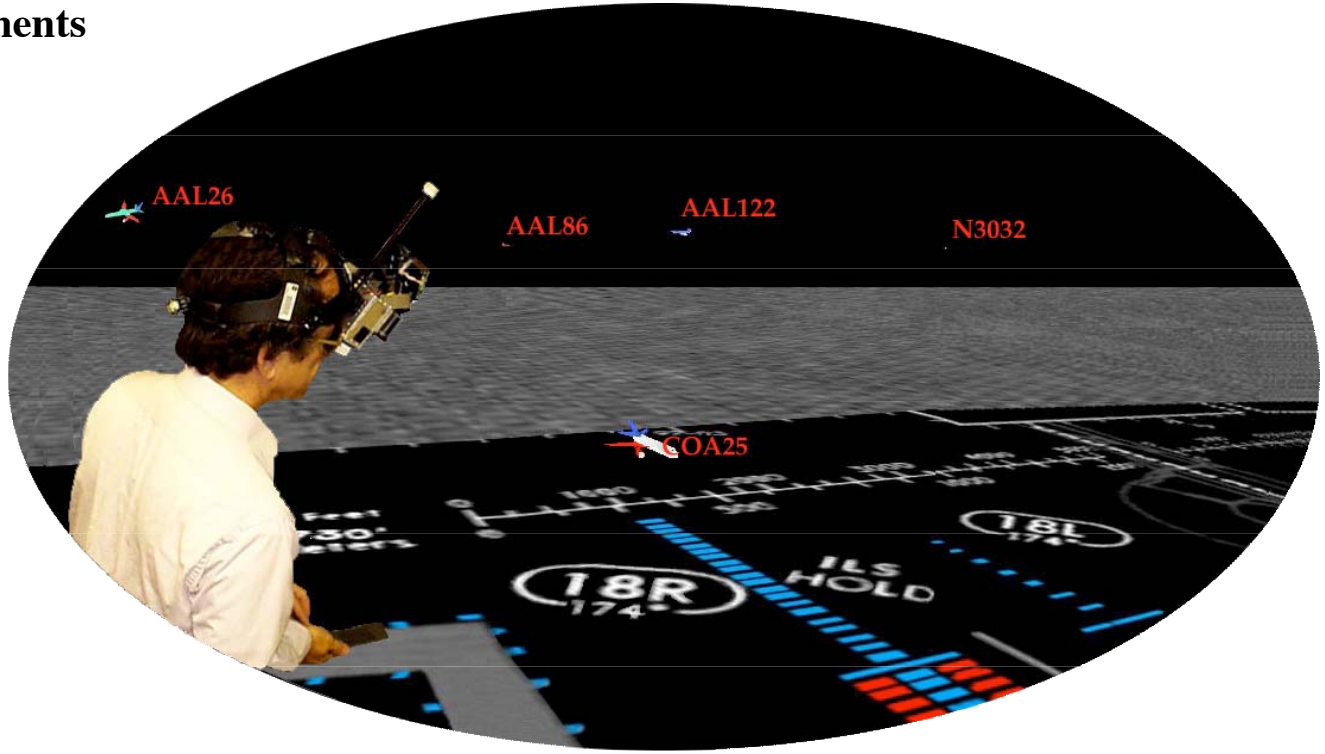
Head-mounted See-through Display
for ARTT Research

Display

- **High fidelity position tracking**
- **High transmisivity combiner**
- **Adjustable binocular overlap**
- **Bright virtual image**
- **Optical adjustments**

Simulation

- **Virtual tower simulation**
- **Integration with CTAS data**
- **Real-time DFW Tower data**



Human Factors Issues for Augmented Reality in the Airport Tower

Perceptual Issues

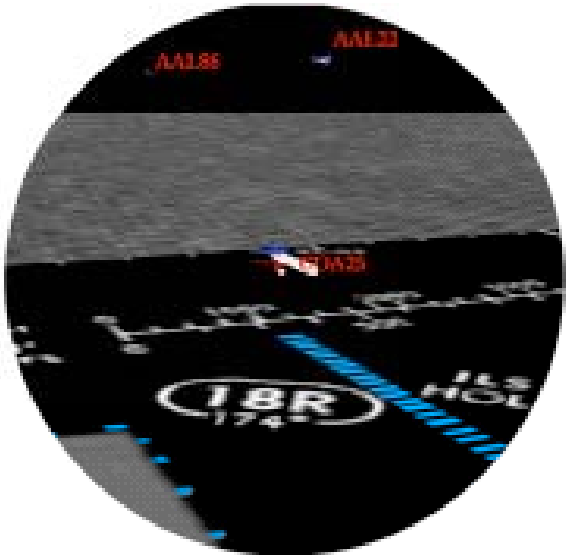
- √ Rendering latency
- Flight data noise and validity
- √ Field of view and field of regard
- Brightness, resolution & focus
- Binocular vision convergence, disparity etc.

Cognitive & Social

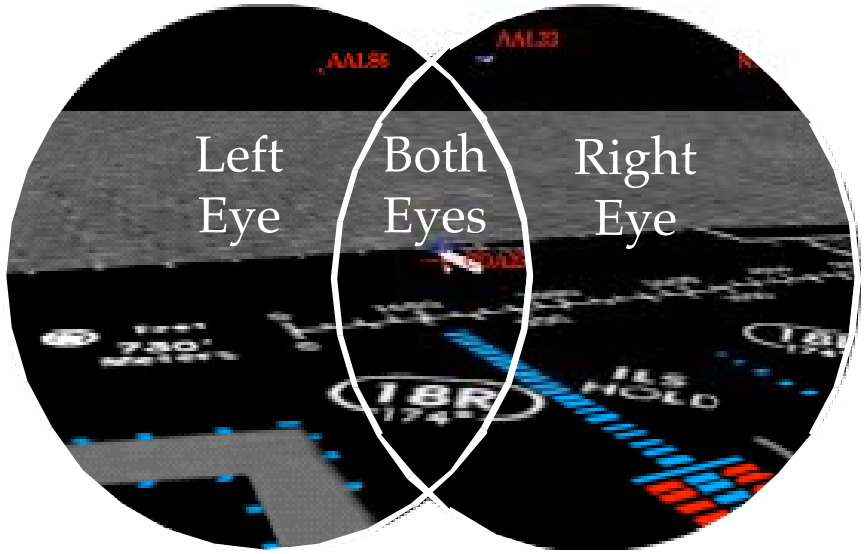
- Data symbology & display format
- Interpersonal communication & phraselogy

Extension of Field of View by Partial Binocular Overlap

Complete Binocular Overlap



Partial Binocular Overlap



Augmented Reality: Field of View Effects on a Aircraft Surveillance Task in a Simulated Tower*

Task: Use see-through HMD to monitor 25 minutes of recorded arriving traffic at Dallas-Ft. Worth Intrnl. Airport using simplified paper Flight Strips to report the appearance(16 a/c) and landing (29 a/c) of 45 aircraft.

Response: Button presses of hand-held control.

Experimental conditions: Three fields of view: 14°, 28°, 47°.

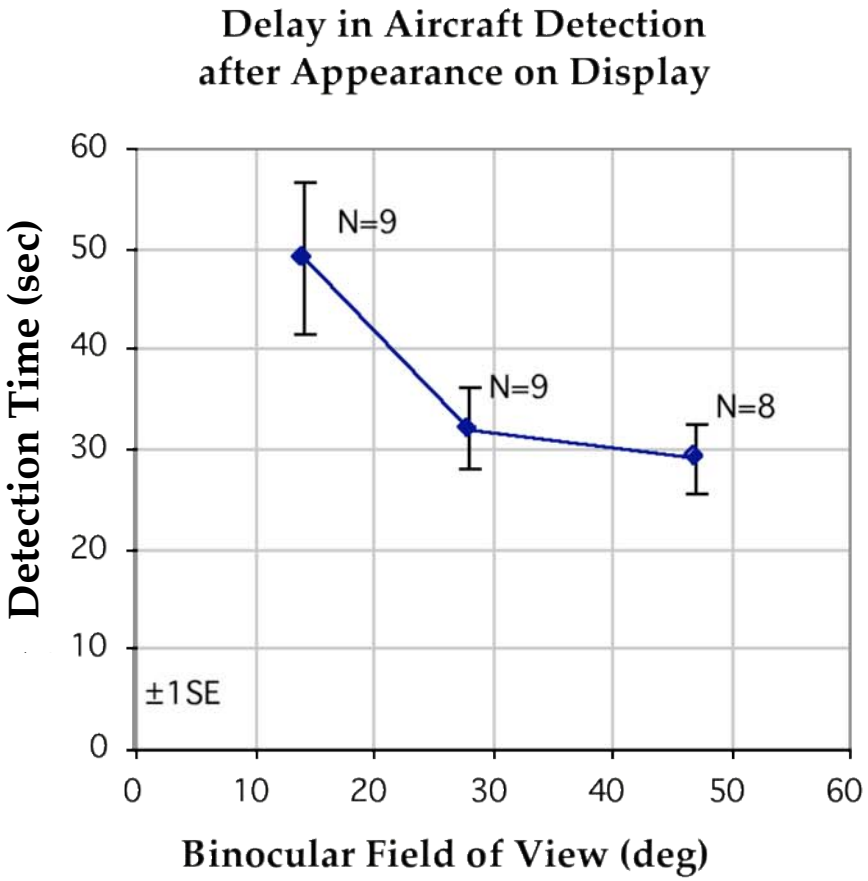
Subjects: 26 trained subjects w/o previous ATC experience, three pilots were distributed across the experimental groups.

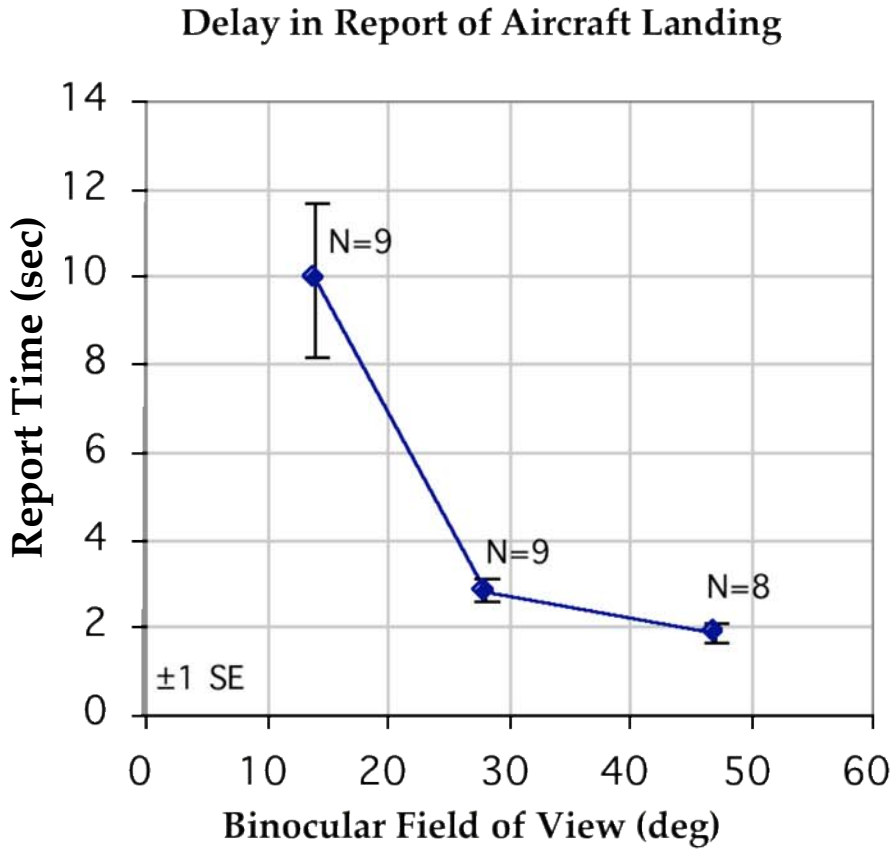
Experimental design: Independent groups n(14°)=9, n(28°)=9, n(47°)=8

Principal response measure: Delay(sec) between time of critical event and its report.

*Schmidt-Ott, J. R., Ellis, S. R., Krozel, J., Reisman, J., Gips, J. (2002) Augmented reality in a simulated tower environment: effect of field of view on aircraft detection. NASA TM 2002-211853 (October, 2002).

Experiment 1.
Effect of HMD Field of View on Surveillance in a Simulated Tower

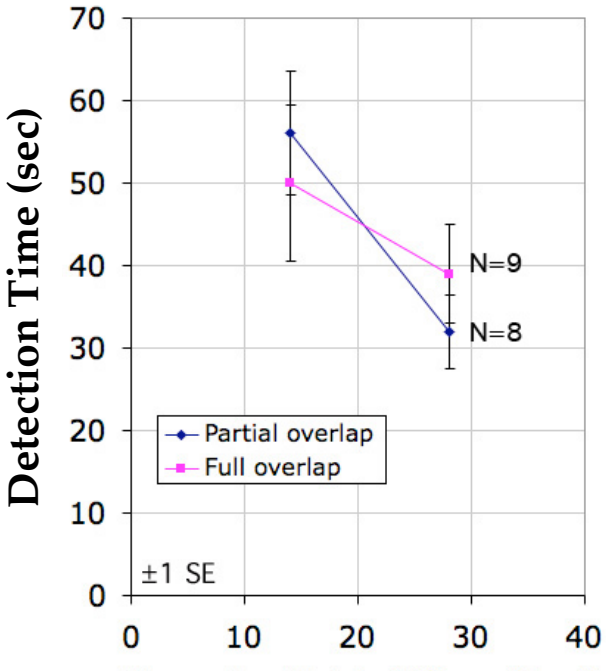




Asymptotic at 55°?

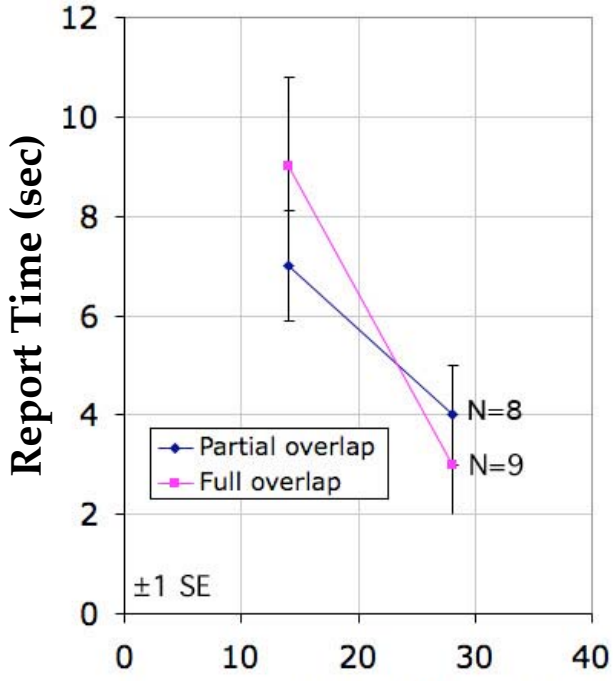
Experiment 2.
Is Surveillance Performance affected by Binocular Overlap?

Delay in Aircraft Detection after Appearance on Display



Binocular Field of View (deg)

Delay in Report of Aircraft Landing



Binocular Field of View (deg)

Answer: NO

Summary

- New display systems can bring the benefits of aircraft HUD's into the airport tower.
- This technology is mature enough to allow the development of prototype systems with user interfaces unlike standard GUI's.
- Previous experience with aircraft HUD's will guide many aspects of human factors design.
- These systems will introduce ergonomic issues new to tower displays. Some have begun to be addressed.

NHK Video clip

The End